BRITISH COLUMBIA
Ministry of Environment and Climate Change Strategy

PROTOCOL 13

FOR CONTAMINATED SITES

Screening Level Risk Assessment

Version 3.1

Prepared pursuant to Section 64 of the *Environmental Management Act*

Approved: Kevin Butterworth — January 09, 2019
Director of Waste Management — Date

1.0 Definitions

The following words, acronyms and expressions used in this protocol are defined in Procedure 8, "Definitions and Acronyms for Contaminated Sites".

- Approved Professional
- beneficial use
- bioaccumulative substances
- conceptual site model
- dense nonaqueous phase liquid [DNAPL]
- Director
- high density urban area
- high risk site
- high water mark
- light nonaqueous phase liquid [LNAPL]
- point of compliance
- potential terrestrial habitat
- preferential pathway
- receiving environment
- receptor
- Regulation
- sensitive habitat
- source parcel
- undeveloped land

2.0 Introduction

This protocol describes the procedures required to complete a screening level risk assessment (SLRA) for a contaminated site in British Columbia. The intention of SLRA is to evaluate whether contamination at a specific site poses acceptable or unacceptable risks to human health and the environment. Such an evaluation includes a simple assessment of exposure pathways and receptors. Contaminated sites that are deemed to have no unacceptable risks (i.e., pass SLRA) are considered to satisfy the risk-based standards of the Contaminated Sites Regulation (the Regulation) and are eligible for a Certificate of Compliance. No further remediation is required at these sites as long as site conditions do not change.

A SLRA completed under this protocol must be carried out by a qualified professional with appropriate demonstrable experience in accordance with Section 63 of the Regulation.

A SLRA completed in accordance with this protocol does not require a Director's decision except as described in Sections 3.2 and 7.0.

SLRA may be used for any substance subject to the requirements specified in this protocol.

3.0 Overview

The SLRA procedure comprises five main steps:

1. Problem formulation (Section 4.1): summarize site conditions and develop a conceptual site model.
2. Check for requirements/precluding conditions/exemptions (Section 4.2): check whether any requirements, precluding conditions, or beneficial use exemptions apply at the site.
3. Evaluation of potential exposure scenarios (Section 4.3): complete the SLRA Questionnaire to assess the potential for human or ecological receptors to be exposed to contaminated soil or groundwater.
4. Determination of risk (Section 4.4): conclude whether contamination at a site poses an acceptable or unacceptable risk based on the SLRA Questionnaire responses.
5. Reporting of SLRA results (Section 5): prepare a summary report in support of the SLRA.

A flow chart summarizing the overall SLRA evaluation process (steps 1 through 4 above) is provided in Figure 1. The flowchart is provided for illustrative purposes only. The Questionnaire must be completed and takes precedence over the flowchart.

3.1 Minimum requirements

Completion of a detailed site investigation (DSI) in accordance with regulatory requirements and ministry approved procedures, guidance and recognized professional practice is required to apply this protocol at a contaminated site. Accordingly, soil, sediment, groundwater, and surface water contamination must be adequately characterized and delineated before a SLRA is carried out.

3.2 Precluding conditions

A Director's decision is required for application of this protocol at high risk sites.

This protocol must not be used to screen the following substances or media at contaminated sites:

- inorganic substances in soil or groundwater with a soil/groundwater pH < 5, respectively;
- bioaccumulative substances;
- contaminated vapour (see Protocol 22, "Application of Vapour Attenuation Factors to Characterize Vapour Contamination" and Technical Guidance 4, "Vapour Investigation and Remediation"); or
- contaminated sediment or surface water except where the contamination qualifies as a beneficial use exemption.

In addition, where the following conditions are present at a contaminated site, the associated exposure pathways are precluded from assessment under this protocol (precluded exposure pathways denoted in brackets). The conditions include:

- deep-rooting plants or trees (root structures extending below 1 m depth) in areas of soil or groundwater contamination at sites where wildlands (natural or reverted), agricultural or low density residential land uses apply (HS and TS pathways);
- very high permeability soil (e.g. cobbles) or complex hydrogeologic units (e.g. fractured bedrock, karst terrain) (HW, AW, IW, LW and default pathways);
- preferential pathways that transport contaminated groundwater directly to a receiving environment or water well (HW, AW, IW, LW and default pathways, as applicable); or
- groundwater contamination that extends beyond a source parcel boundary and is not demonstrated to be stable or decreasing (HW, AW, IW, LW and default pathways, as applicable). See section 6.0 for requirements related to demonstration of plume stability.

This protocol must also not be used to screen exposure pathways that are not specifically identified in this protocol (e.g., exposure of subsurface workers to operative chronic occupational exposures).

3.3 Beneficial use exemption

Soil, sediment, groundwater or surface water contamination that does not extend significantly beyond (i.e., more than 3 m laterally from) an eligible beneficial use is not considered to constitute an unacceptable risk. Specific contaminants and eligible beneficial uses include the following:

- zinc localized around galvanized materials (used to prevent rusting);
- copper localized around copper pipe or bare copper wire (used for water supply or for cathodic protection to prevent corrosion);
- boron, chromium, copper, arsenic, chlorophenols, or constituents of creosote (including petroleum hydrocarbon carrier solutions) localized around treated or preserved wood utility poles, structural timber or pilings; and
- road salting (lateral distance as measured from the pavement edge or from the edge of the travelled portion of unpaved roads).

The beneficial use exemption is applicable at active or closed sites as long as the beneficial use applies. The beneficial use exemption is not applicable where the use is historical and no longer serves its intended purpose. The exemption also does not apply at sites where the beneficial use materials were produced or stored.

4.0 Methodology

4.1 Problem formulation

The problem formulation step (Step 1) involves reviewing site information, summarizing site conditions, and preparing a conceptual site model. The objectives of this step are to summarize relevant site information for purposes of:

- identifying site conditions (contamination sources, pathways and receptors) that could give rise to unacceptable risks;
- identifying information gaps requiring further investigation in order to evaluate potential exposure pathways;
- identifying any risk management measures to be implemented/implemented if SLRA is conducted pre-/post-remediation of the site, respectively;
- identifying exposure pathways which must be assessed outside of SLRA; and
- enabling the determination of risk.

For purposes of this protocol, contaminant source areas in soil are areas where substance concentrations in soil (soil concentrations) exceed the applicable generic/matrix numerical soil standards, background concentrations, or site-specific numerical soil standards.

Once site conditions have been reviewed and summarized, a conceptual site model must be prepared. The conceptual site model must describe the:

- source and distribution of contaminants (how contamination developed and its current and potential future extent) with consideration of seasonal effects, long-term trends and plume stability;
- fate and transport pathways (how contaminants behave in the subsurface and how they might be transported and where); and
- receptors (who or what may be affected).

The conceptual site model must also be illustrated in a graphic or flowchart format (e.g., as shown in Figure 2) that clearly shows the linkages between contamination sources, exposure pathways, and receptors.

4.2 Check for requirements, precluding conditions, and exemptions

Following preparation of the problem formulation, the next step (Step 2) is to check whether any requirements, precluding conditions or beneficial use exemptions apply at the site. Requirements are described in Section 3.1 and precluding conditions are described in Section 3.2. Exemptions for contamination due to eligible beneficial uses are described in Section 3.3.

4.3 Evaluation of potential exposure scenarios

The third step (Step 3) is to evaluate whether human or ecological receptors are likely to be exposed to potentially harmful concentrations of substances in soil or groundwater. Potentially harmful concentrations are those that exceed:

- generic numerical soil standards (CSR Schedule 3.1 (Parts 2 and 3));
- matrix numerical soil standards (CSR Schedule 3.1 (Part 1));
- background soil concentrations as established under Protocol 4, "Establishing Background Concentrations in Soil";
- site-specific numerical soil standards developed under Protocol 2, "Site-Specific Numerical Soil Standards";
- generic numerical water standards (CSR Schedule 3.2);
- background groundwater concentrations as established under Protocol 9, "Determining Background Groundwater Quality";
- site-specific numerical groundwater standards for zinc developed under Protocol 10, "Hardness Dependent Site-Specific Freshwater Standards for Zinc"; or
- Director's interim standards or criteria.

The SLRA Questionnaire is completed in this step. The questionnaire has seven series of questions that qualitatively assess whether potential exposure pathways are complete or operative for six exposure pathways and one default pathway. The exposure pathways are summarized as follows:

- The first two pathways evaluate the potential for human exposure to contaminated soils (questions HS-1 to HS-3) and groundwater (questions HW-1 to HW-3).
- The third pathway evaluates the potential for terrestrial biota to be exposed to contaminated soil (questions TS-1 to TS-5).
- The following three pathways evaluate the potential for exposure of aquatic biota, crops, and livestock to contaminated groundwater (questions AW-1 to AW-3, IW-1 to IW-3, and LW-1 to LW-3, respectively).
- The remaining pathway evaluates the potential for exposure to groundwater contamination greater than default numerical environmental quality standards (questions DF-1 and DF-2).

All seven exposure pathways must be evaluated. However, it may not be necessary to answer all questions within each of the exposure pathway series.

Questions should be answered in the sequence indicated and require a "yes" or "no" response. Some questions may also require the provision of supporting rationale, figures, tables, calculations or forms (as indicated in the notes section of the questionnaire). A "yes" response to any question indicates the potential presence of a contaminant, pathway, or receptor and "yes" responses to all questions within an exposure pathway series indicates the exposure pathway is a complete and operative pathway. A "no" response to any question within an exposure pathway series indicates that a contaminant, pathway or receptor is not present for that pathway and that the pathway is inoperative. If a "no" response is provided to a given question within a series, then the remaining questions in that series need not be answered (see Figure 1).

4.4 Determination of risk

The results of the SLRA Questionnaire are used to determine whether contamination at a site poses acceptable or unacceptable risks.

Sites for which there are "yes" responses to all questions within an exposure pathway series are considered to have an operative exposure and unacceptable risk for that pathway. Sites that have an unacceptable risk for one or more exposure pathways are considered to fail the SLRA. Further remediation – or completion of a detailed risk assessment – is necessary for these sites to address the failed exposure pathways.

Sites for which a "no" response was provided for at least one question within each of the seven exposure pathways series (i.e., all pathways are inoperative) are considered to have no unacceptable risks. Provided all requirements of this protocol and the Regulation are satisfied, these sites are deemed to satisfy the risk-based standards of the Regulation and are eligible for a Certificate of Compliance. No remediation is required for the specified land and water uses as long as conditions at the site remain the same.

5.0 Reporting

A SLRA report must be completed in accordance with this protocol. At a minimum, a SLRA report must include:

- a summary description of the site conditions, the environmental investigations completed, and any remediation conducted;
- a conceptual site model including diagrams summarizing site conditions and linkages between contaminants, exposure pathways, and receptors (see the example in Figure 2);
- a completed SLRA Questionnaire and supporting diagrams, plan maps, cross sections, and forms (e.g., Forms A-1, A-2, B-1, B-2, and B-3, as appropriate);
- a digital spreadsheet file with calculations/output where the ministry's Groundwater Protection Model is used (see Appendix A);
- a modeling report including digital simulation/output files where BIOSCREEN is used (see Appendix A);
- the reporting requirements under section 7.0 of Protocol 27, "Soil Leaching Tests for Use in Deriving Site-Specific Numerical Soil Standards" if leachate testing is undertaken (as per Appendix A);

- specification of any eligible beneficial uses (including associated contaminants and contaminated media);
- specification of any precluding conditions and how these were addressed outside of SLRA (e.g., Director's approval obtained for a high risk site, exposure pathways not available for screening in SLRA that were carried forward to DRA);
- specification of the contaminants addressed in the SLRA;
- specification of any risk management measures implemented;
- specification of any risk controls to be included in a performance verification plan (e.g., prescribed long term monitoring and maintenance measures to be implemented to ensure the long term integrity of any surface barriers, if present at the site);
- conclusions regarding whether contamination at a site poses acceptable or unacceptable risks; and
- a written signed statement prepared by a qualified professional confirming:
  - they have demonstrable experience in the investigation and assessment of contaminated sites; and
  - that the SLRA for which documentation is provided has been completed in accordance with this protocol.

6.0 Plume stability

The demonstration of stable or decreasing contaminant plumes must include the evaluation of groundwater conditions within and at the margins of contaminant plumes and provide evidence of both stable or decreasing substance concentrations and no additional vertical or lateral migration or rebound effects. A minimum of 2 years of groundwater monitoring and geochemical data (including seasonal variations over a 2 year period) demonstrating stable or decreasing groundwater concentrations and conditions is necessary. Additional guidance on the assessment of plume stability can be found in Technical Guidance 8 "Groundwater Investigation and Characterization".

Where plume stability is demonstrated, completion of the groundwater contaminant transport pathway assessment component of SLRA (Appendix A) is not necessary.

7.0 Director's decision of alternative methods

Site owners and operators may request a Director to make a decision on the use of alternative methods as part of the groundwater contaminant transport pathway assessment component of SLRA (Appendix A).

Examples of alternative methods that would be considered by the Director for use under Appendix A, where demonstrated to be scientifically defensible, include:

- use of site-specific parameter values outside the parameter ranges provided in the protocol or Groundwater Protection Model (see Appendix A); or
- use of site-specific parameter values instead of the default values provided in the protocol or Groundwater Protection Model (see Appendix A).

A request for a Director's decision based on the above must be accompanied by a completed Contaminated Sites Services Application form and a supporting technical report prepared by a qualified professional. The technical report must include documentation of the site-specific parameter values used and description of the methodology used to obtain those values.

8.0 References

1. B.C. Ministry of Environment. (2017). British Columbia Environmental Laboratory Manual, 2017 Edition. http://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/sampling-methods-quality-assurance/bc-environmental-laboratory-manual

2. United States Department of Energy. Risk Assessment Information System (RAIS), Toxicity & Chemical Specific Factors Data Base. https://rais.ornl.gov/

3. Kool, J.B, Huyakorn, P.S., Sudicky, E.A., Saleem, Z.A. (1994). A Composite Modeling Approach for Subsurface Transport of Degrading Contaminants from Land-Disposal Sites. Journal of Contaminant Hydrology, 17. 1994.

4. Domenico, P.A. (1987). An Analytical Model for Multidimensional Transport of a Decaying Contaminant Species. Journal of Hydrology, 91. 1987

5. United States Environmental Protection Agency. (1996). BIOSCREEN, Natural Attenuation Decision Support System. EPA/600/R-96/087. August, 1996. https://www.epa.gov/water-research/bioscreen-natural-attenuation-decision-support-system

6. Syracuse Research Corporation (SRC), Inc. Fate Pointer File: Physical Properties Database (PHYSPROP). http://esc.syrres.com/fatepointer/search.asp

7. Syracuse Research Corporation (SRC), Inc. Fate Pointer File: HSDB National Library of Medicine Toxicology Data Network (TOXNET). http://esc.syrres.com/fatepointer/search.asp

8. Canadian Council of Ministers of the Environment. (2001). Canada-Wide Standard for Petroleum Hydrocarbons (PHC) in Soil: Scientific Rationale Supporting Technical Document. April, 2001. http://www.ccme.ca/en/resources/contaminated_site_management/phc_cws_in_soil.html

9. Axiom Environmental Inc. (2011). Proposed Values of Biodegradation Rate for Organic Chemicals for Use in the British Columbia CSST Model (draft). March 2011. https://www2.gov.bc.ca/gov/content/environment/air-land-water/site-remediation/guidance-resources/discussion-papers-and-reports

10. United States Environmental Protection Agency. (1996). Soil Screening Guidance. https://www.epa.gov/superfund/superfund-soil-screening-guidance

11. B.C. Ministry of Environment. Derivation of Proposed 2007 Draft Matrix Soil Standards for Barium. http://www2.gov.bc.ca/assets/gov/environment/air-land-water/site-remediation/docs/requests-for-comments-archive/deriv_07_soil_stand_barium.pdf

12. B.C. Ministry of Environment. Finalization of Proposed 2007 Final Draft Matrix Soil Standards for Sodium (Na+) and Chloride (Cl-). http://www2.gov.bc.ca/assets/gov/environment/air-land-water/site-remediation/docs/requests-for-comments-archive/soil_stand_salt.pdf

13. B.C. Ministry of Environment. Overview of Contaminated Sites Soil Task Group (CSST) Procedures for the Derivation of Soil Quality Matrix Standards for Contaminated Sites. Ministry of Environment, Lands and Parks. January 31, 1996. http://www2.gov.bc.ca/assets/gov/environment/air-land-water/site-remediation/docs/policies-and-standards/overview_of_csst_procedures-derivation_of_soil_quality_matrix_standards_cs.pdf

14. Royal Roads University. Derivation of Matrix Soil Standards for Salt under the British Columbia Contaminated Sites Regime. June 2002. http://www2.gov.bc.ca/assets/gov/environment/air-land-water/site-remediation/docs/requests-for-comments-archive/rev_prov_saltmatrix.pdf

For more information, please direct inquiries to site@gov.bc.ca.

Revision history

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July 7, 2008	August 1, 2008	V2	
November 1, 2017	November 1, 2017	V3	Updated as part of the Stage 10 Amendment to the CSR.
January 9, 2019	January 9, 2019	V3.1	Miscellaneous amendments.

APPENDIX A

Soil Leachate and Groundwater Transport Assessment (Questions HW-3, AW-3, LW-3, IW-3 and DF-2 in SLRA Questionnaire)

The soil leachate and groundwater transport assessment component of SLRA considers the potential for contaminated groundwater to migrate to a downgradient point of compliance using a contaminant fate and transport model. A point of compliance is used as a proxy for a receptor and, as outlined in Section 3.2 of this protocol, is the downgradient boundary of the contaminant source parcel. Contaminated groundwater may originate from both soils (i.e. soil leachate) and groundwater within a contaminant source area.

This assessment involves four steps:

1) determination of substance concentrations in soil leachate (leachate concentrations) in the contaminant source area (contaminant partitioning from soil to infiltrating water);
2) calculation of predicted leachate concentrations at the water table (leachate fate and transport through the unsaturated zone);
3) calculation of predicted substance concentrations in groundwater (groundwater concentrations) in the saturated zone (mixing of leachate and groundwater in the saturated zone); and
4) calculation of predicted groundwater concentrations at the point of compliance (solute fate and transport in the saturated zone).

Steps 1, 2 and 3 must be completed. Step 4 need only be completed if predicted groundwater concentrations in the saturated zone, or maximum measured groundwater concentrations, exceed the applicable CSR water standards.

The ministry's Groundwater Protection Model (GPM) is the default model used for leachate and groundwater transport assessment in SLRA. The GPM is the model used to calculate the CSR matrix numerical soil standards under Protocol 28, "2016 Standards Derivation Methods" and site-specific numerical soil standards under Protocol 2. The GPM is used in the backward mode for calculating matrix and site-specific numerical soil standards (i.e., groundwater to soil) and in the forward or predictive mode (i.e., soil to groundwater) for conducting SLRA. The GPM is available in Technical Guidance 13, "Groundwater Protection Model". Derivation and supporting information on the GPM is available in Protocol 28.

SLRA model equations are provided at the end of this appendix.

1.0 Determination of predicted soil leachate concentrations in source area

Leachate concentrations in the source area (C_L) must be determined for inorganic substances using an approved soil leaching test. For inorganic substances not prescribed in an approved soil leaching test (e.g., cyanide), leachate concentrations must be calculated using a partitioning equation. For organic substances, leachate concentrations may be determined using an approved soil leaching test or calculated using a partitioning equation. Leachate concentrations in the source area, and parameter values used to derive them, must be summarized on **Form A-1**.

1.1 Inorganic substance leachate concentrations (using leachate test)

For inorganic substances prescribed in an approved soil leaching test, where soil pH is 5 or greater, the procedures and requirements outlined in Sections 4 through 6 of Protocol 27 must be followed to determine predicted leachate concentrations. The laboratory method used for leachate testing of inorganic substances in soils, with the exception of chloride ion and sodium ion, is the "Liquid-Solid Partitioning (Leachability) as a Function of pH (Metals, Inorganics, and SVOCs) – Prescriptive" (BC Soil Leachate Test) as provided in the BC Environmental Laboratory Manual [1]. For chloride ion and sodium ion, the approved leaching test is the "Saturated Paste Extraction for Soils" (BC Saturated Paste Extraction Test) laboratory method provided in the BC Environmental Laboratory Manual [1].

The inorganic substances that must be evaluated using the BC Soil Leachate Test or BC Saturated Paste Extraction Test under SLRA are identified in the respective leachate tests.

1.2 Organic substance leachate concentrations (using leachate test)

Leachate testing may also be conducted for certain organic substances in soil. If leachate testing is undertaken for these substances, the procedures and requirements outlined in Sections 4 through 6 of Protocol 27 must be followed to determine predicted leachate concentrations.

There are two laboratory methods available for leachate testing of organic substances depending on the volatility of the substance. The laboratory methods consist of:

- Liquid-Solid Partitioning (Leachability) of VOCs – Prescriptive (BC VOC Soil Leachate Test) as provided in the BC Environmental Laboratory; and
- BC Soil Leachate Test.

The organic substances that may be evaluated using the BC VOC Soil Leachate Test or BC Soil Leachate Test under SLRA are identified in the respective leachate tests.

1.3 Organic/inorganic substance leachate concentrations (using partitioning equations)

Leachate concentrations for organic substances may also be calculated using partitioning equations (Equation A-1) and measured soil concentrations. This approach must be used for organic substances for which there is no available soil leachate test in Protocol 27. In addition, where soil pH is 5 or greater, this approach must be used for inorganic substances for which there is no available leachate test in the BC Soil Leachate Test or BC Saturated Paste Extraction Test.

Under this approach, the soil concentrations used in Equation A-1 must be based on a minimum of three soil samples collected from the contaminant source area. These samples must have substance(s) concentrations equal to or greater than the 90th percentile of measured concentrations of the substance(s), as confirmed by laboratory analysis. Where the contaminant source area or volume of contaminated soil is greater than 300 m^2 or 900 m^3, respectively, or where soil contamination is heterogeneous and randomly distributed (e.g. contaminated fill), additional soil samples above the minimum requirement, proportionate with the larger extent of contamination or heterogeneity of the soil, must be included in the determination of the soil concentration to be used in Equation A-1.

Predicted leachate concentrations must be calculated for each substance using the arithmetic mean of the measured soil concentrations for each substance with property values for organic carbon partitioning coefficient (K_{oc}), dimensionless Henry's law constant (H'), or distribution coefficient (K_d) from Table A-1. For substances not listed in Table A-1, substance property values for K_{oc}, H' and K_d must be obtained from the US Environmental Protection Agency Risk Assessment Information System (RAIS)[2].

A site-specific or default value for fraction of organic carbon (f_{oc}) must be used in Equation A-1. Site-specific or literature values may be substituted for parameters with default values (n, n_a, n_w, ρ_b) in Equation A-1.

2.0 Calculation of predicted soil leachate concentrations at the water table

The predicted leachate concentrations at the water table (C_z) are calculated using a one dimensional steady-state solution (Equation A-2) to the advection-dispersion equation for contaminant transport in the unsaturated zone (modified from Kool *et al*) [3]. In this step, the measured or calculated predicted leachate concentrations in the contaminant source area are used as the source concentration (C_L) in Equation A-2. The leachate concentrations used in Equation A-2 are obtained from 1.1 through 1.3 above, as applicable.

Predicted leachate concentrations at the water table must be calculated for each substance with property values for K_{oc} and unsaturated zone biodegradation half-life ($t_{1/2u}$) from Tables A-1 and A-2 (for organic substances) and distribution coefficient (K_d) values from Tables A-3 and A-4 (for inorganic substances). Where an unsaturated zone biodegradation half-life is not specified for an organic substance, or for any inorganic substance, a default value of 1E+99 days must be used.

For substances not listed in Table A-1, substance property values for K_{oc} and K_d must be obtained from the RAIS database [2].

Site-specific values must be used for parameters d, Z, and I in Equation A-2. Procedures for determining site-specific values of source depth (Z) and infiltration rate (I) are provided in Protocol 2. Where a discrete value of source depth cannot be determined using Protocol 2, the applicable numerical soil standards must be used to define the source depth. A site-specific or default value for f_{oc} must be used in Equation A-2. Site-specific or literature values may be substituted for parameters with default values (n_w, ρ_b) in Equation A-2.

Predicted leachate concentrations at the water table, and parameter values used to calculate them, must be summarized on **Form A-1**.

3.0 Calculation of predicted groundwater concentrations in the saturated zone

The predicted groundwater concentrations below the source area ($C_{gw'}$) are calculated using a dilution factor (DF) to account for mixing across the water table. In this step, the predicted leachate concentrations at the water table (C_z from 2.0 above) are divided by the dilution factor. Equation A-3 is used to calculate the predicted groundwater concentrations in the saturated zone.

Predicted groundwater concentrations must be calculated for each substance using site-specific values for the parameters K, i, X, I and d_a in Equations A-3 and A-4. Procedures for determining site-specific values of source length (X) and infiltration rate (I) are provided in Protocol 2. Where a discrete value of source length cannot be determined using Protocol 2, then the applicable numerical soil standards must be used to define the source length. A minimum value of 0.08 m/yr must be used for the infiltration rate. The remaining site-specific parameters (K, i, and d_a) must be determined based on a site-specific hydrogeological investigation.

In Equation A-3, a value of one (1) must be used for the dilution factor (DF) where the soil contamination source extends into the water table. In Equation A-4, where the mixing zone thickness (d_m) is calculated at greater than the aquifer thickness (d_a), the mixing zone thickness term must be set equal to the aquifer thickness.

Predicted groundwater concentrations in the saturated zone, and parameter values used to derive them, are to be summarized on **Form A-1**.

The final component of Step 3 is to determine whether any predicted groundwater concentrations exceed the corresponding CSR numerical water standards.

- If "yes" for any contaminant, then proceed to Step 4 to calculate predicted groundwater concentrations at the point of compliance for those contaminants.
- If "no" for all contaminants, but measured groundwater concentrations exceed CSR numerical water standards for some or all of the contaminants, proceed to Step 4 to calculate predicted groundwater concentrations at the point of compliance based on groundwater data for those contaminants.
- If "no" for all contaminants, and measured groundwater concentrations are less than CSR numerical water standards for all contaminants, then enter a "no" response to Question HW-3, AW-3, IW-3, or LW-3, as appropriate (i.e., soil to groundwater contaminant transport pathway is incomplete).

4.0 Calculation of predicted groundwater concentrations at the point of compliance

Predicted groundwater concentrations at the point of compliance (C_x) are calculated using the Domenico two-dimensional steady-state solution [4] to the advection-dispersion equation for contaminant transport (Equation A-5). Following from Step 3, for each substance, the predicted groundwater concentration below the source ($C_{gw'}$) or maximum measured groundwater concentration below the source (C_{gwmax}), whichever is greatest, is used as the source concentration (C_{gw}) in Equation A-5.

Predicted groundwater concentrations at the point of compliance must be calculated for each substance with property values for K_{oc} and saturated zone biodegradation half-life ($t_{1/2s}$) from Tables A-1 and A-2 (for organic substances) and distribution coefficient (K_d) values from Tables A-3 and A-4 (for inorganic substances). Where a saturated zone biodegradation half-life is not specified for an organic substance, or for any inorganic substance, a default value of 1E+99 days must be used.

For substances not listed in Table A-1, substance property values for K_{oc} and K_d must be obtained from the RAIS database [2].

Site-specific values must be used for parameters C_{gwmax}, x, K, i and Y in Equation A-5. The allowable value for distance to point of compliance (x) is dependent on the applicable water use and is measured from the downgradient edge of the contaminant plume or, where groundwater contamination is not present, the downgradient boundary of the source length (X). For DW, IW and LW water use, the point of compliance is a water well on the parcel or the parcel boundary, whichever is lesser. For AW water use, the point of compliance is 10 m from the high water mark of a receiving environment on the parcel or the parcel boundary, whichever is lesser. The maximum allowable value for x is 500 m regardless of water use.

The remaining site-specific parameters (C_{gwmax}, x, K, and i) must be determined based on site-specific hydrogeological investigation. A minimum value of 5 m/yr must be used for the average linear groundwater velocity. A site-specific or default value for f_{oc} must be used in Equation A-5. Site-specific or literature values may be substituted for parameters with default values (n, n_e, ρ_b) in Equation A-5.

Predicted groundwater concentrations at the point of compliance, and parameter values used to calculate them, are to be summarized on **Form A-2**.

In addition to using the ministry's GPM model for calculating predicted groundwater concentrations at the point of compliance, the public domain model BIOSCREEN [5] may be used as the groundwater contaminant transport model, in place of Equation A-5, provided:

- a constant (non-declining) source is specified;
- biodegradation is modeled as a first-order decay process;
- simulations are conducted to steady-state conditions;
- the vertical transverse dispersivity is set to 0 m;
- values for transport parameters are as specified for Equation A-5; and
- a modeling report is provided including tabulated data similar to **Form A-2** and simulation files on electronic media, along with specification of all parameter values, simulation results, and sensitivity analyses.

The final component of Step 4 is to determine whether any predicted groundwater concentrations at the point of compliance exceed the corresponding CSR numerical water standards.

- If "yes" for any contaminant or sample location, then enter a "yes" response to Question HW-3, AW-3, IW-3, or LW-3, as appropriate (i.e., contamination has the potential to reach a receptor). The site fails the screening level risk assessment for this exposure scenario.
- If "no" for all contaminants and sample locations, then enter a "no" response to Question HW-3, AW-3, IW-3, or LW-3, as appropriate (i.e., contamination does not have the potential to reach a receptor). The site passes the screening level risk assessment for this exposure scenario.

Forms A-1 and A-2 are located in the SLRA Questionnaire and Forms attachment. See Figure 3 for a summary graphical depiction of the soil leachate and groundwater transport assessment process.

Appendix A

SLRA Model Equations

Soil/leachate partitioning
Equation A-1:

From EPA SSG [10]:

$$C_L = \frac{C_s}{\left[K_d + \left(\frac{n_w + H' n_a}{\rho_b}\right) \right]} * 1000$$

$$K_d = K_{oc} f_{oc}$$

$$n_a = n - n_w$$

C_L = leachate concentration at source (µg/L)
C_s = soil concentration at source (µg/g)
K_d = distribution coefficient (L/kg)
K_{oc} = organic carbon partitioning coefficient (L/kg, Table A-1)
f_{oc} = fraction of organic carbon (site-specific or default value of 0.5%)
n_w = water-filled porosity (default value 0.119)
n_a = air-filled porosity (default value 0.241)
n = total porosity (default value 0.36)
H' = dimensionless Henry's law constant (Table A-1)
ρ_b = dry bulk density of soil (default value 1.7 g/cm^3)
1000 = conversion factor (1000 µg/mg)

Equation A-2:
Leachate transport in the unsaturated zone

Unsaturated zone transport as modified from Kool *et al.*, 1994 [3]:

$$C_z = C_L * \exp\left[\frac{b}{2\,\partial_u}\left(1 - \left(1 + \frac{4\lambda_u\,\partial_u R_u}{v_u}\right)^{1/2}\right)\right]$$

$$b = d - Z$$

$$\partial_u = 0.1b$$

$$\lambda_u = \frac{\ln 2}{t_{1/2u}} \text{ where } \ln 2 = 0.6931$$

$$R_u = 1 + \frac{\rho_b}{n_w} K_d$$

$$v_u = \frac{I}{n_w} \text{ and } I = P - (RO + EV)$$

C_z = leachate concentration at water table (μg/L)
C_L = leachate concentration at source (μg/L) – from soil leachate tests or Equation A-1, as applicable.
b = vertical distance between base of source and water table (m)
d = depth to water table (site-specific value (m))
Z = source depth (site-specific value (m))
∂_u = dispersivity in unsaturated zone (m)
λ_u = biodegradation rate in unsaturated zone ($days^{-1}$ * 365 days/yr)
$t_{1/2u}$ = half-life in unsaturated zone (days, Table A-1)
R_u = retardation factor in unsaturated zone
v_u = leachate velocity in unsaturated zone (m/yr)
I = infiltration rate (site-specific value, minimum value of 0.08 m/yr)
P = precipitation rate (m/yr)
RO+EV = runoff plus evapotranspiration rate (m/yr)

Equation A-3:

Leachate/groundwater mixing

From EPA SSG [10]:

$$C_{gw'} = \frac{C_z}{DF} \text{ where } DF = 1 + \left(\frac{d_m V}{X\,I}\right)$$

$DF = 1$ if $b < 0$ (source extends into water table)

$V = K\,i$

$C_{gw'}$ = predicted groundwater concentration below source (μg/L)
C_z = leachate concentration at water table (μg/L) – from Equation A-2
DF = dilution factor
d_m = mixing zone thickness (Equation A-4)
V = Darcy flux or specific discharge (site-specific value (m/yr))
K = hydraulic conductivity (site-specific value (m/s*3.154E+07 s/yr))
i = hydraulic gradient (site-specific value)
X = source length (site-specific value (m))

Equation A-4:

Leachate/groundwater mixing – mixing zone thickness

From EPA SSG [10]:

$$d_m = 0.1X + d_a\left[1 - \exp\left(-\frac{XI}{Vd_a}\right)\right] \text{ or } d_a\text{, whichever is lesser}$$

d_m = mixing zone thickness (m)
d_a = aquifer thickness (site-specific value (m))

Equation A-5:

Solute transport in the saturated zone

2D saturated transient analytical transport solution from Domenico, 1987 [4]:

$$C_x = C_{gw}\ \exp\left\{\frac{x}{2\,\partial_x}\left[1-\left(1+\frac{4\lambda_s\,\partial_x R_f}{v}\right)^{1/2}\right]\right\}\ \mathrm{erf}\left[\frac{Y}{4\left(\partial_y x\right)^{1/2}}\right]$$

$$C_{gw} = \max\left(C_{gw'},\ C_{gwmax}\right)$$

$$\partial_x = 0.1x \ \text{ and } \ \partial_y = 0.1\,\partial_x$$

$$\lambda_s = \frac{\ln 2}{t_{1/2s}} \text{ where } \ln 2 = 0.6931$$

$$R_f = 1 + \frac{\rho_b}{n}K_d \text{ where } K_d = K_{oc}f_{oc}$$

$$v = \frac{V}{n_e} = \frac{K\,i}{n_e}$$

C_x = predicted groundwater concentration at point of compliance (µg/L)
C_{gw} = groundwater concentration below source (µg/L) = greater of $C_{gw'}$ and C_{gwmax}
$C_{gw'}$ = predicted groundwater concentration below source (µg/L) – from Equation A-3
C_{gwmax} = maximum measured groundwater concentration below source (site-specific value (µg/L))

x = distance to point of compliance (site-specific value (m)). Maximum allowable value is 500 m.

> The point of compliance is dependent on the water use as follows:
> For DW/IW/LW – a water well on the parcel or the parcel boundary, whichever is lesser; and,
> For AW – 10 m inland from the high water mark of a receiving environment on the parcel or the parcel boundary, whichever is lesser.

∂_x = longitudinal dispersivity (m)
∂_y = transverse dispersivity (m)
λ_s = biodegradation rate in saturated zone (days^{-1}*365 days/yr)
$t_{1/2s}$ = half-life in saturated zone (days, Table A-1)
R_f = retardation factor in saturated zone
v = average linear groundwater velocity in saturated zone (site-specific value, minimum value of 5 m/yr)
n_e = effective porosity (default value 0.25)
Y = source width (site-specific value (m)) = maximum extent of contaminated groundwater perpendicular to the groundwater flow direction

Appendix A

Table A-1 Substance properties

Substance	Chemical Abstract Service # (CAS)	Henry's Law Constant H' (-)		Organic Carbon Partitioning Coefficient Koc (L/kg)		Biodegradation Half-life Unsaturated t1/2u (days)		Biodegradation Half-life Saturated t1/2s (days)	
		Value	Reference	Value	Reference	Value	Reference	Value	Reference
acenaphthene	83-32-9	0.00752	RAIS	5,030	RAIS	145	Axiom	290	Axiom
acetone	67-64-1	0.00143	RAIS	2.36	RAIS	95	Axiom	190	Axiom
acrolein	107-02-8	0.00499	RAIS	1	RAIS				
acrylonitrile	107-13-1	0.00564	RAIS	8.51	RAIS				
allyl chloride	107-05-1	0.450	RAIS	39.6	RAIS				
aluminum	7429-90-5	-		-		-		-	
anthracene	120-12-7	0.00227	RAIS	16,400	RAIS	195	Axiom	390	Axiom
antimony	7440-36-0	-		-		-		-	
arsenic	7440-38-2	-		-		-		-	
barium	7440-39-3	-		-		-		-	
benz(a)anthracene	56-55-3	4.91E-04	RAIS	177,000	RAIS				
benzene	71-43-2	0.227	RAIS	146	RAIS	195	Axiom	390	Axiom
benzo(a)pyrene	50-32-8	1.87E-05	RAIS	587,000	RAIS				
benzo(b+j)fluoranthenes[1]	205-99-2 & 205-82-3	8.30E-06	RAIS	599,000	RAIS				
benzotrichloride	98-07-7	0.0106	RAIS	1,000	RAIS				
benzyl chloride	100-44-7	0.0168	RAIS	446	RAIS				
beryllium	7440-41-7	-		-		-		-	
bis(2-chloro-1-methylethyl) ether	108-60-1	0.00303	RAIS	82.9	RAIS				
bis(2-chloroethyl) ether	111-44-4	6.95E-04	RAIS	32.2	RAIS				
boron	7440-42-8	-		-		-		-	
bromobenzene	108-86-1	0.101	RAIS	234	RAIS				
bromodichloromethane [BDCM]	75-27-4	0.0867	RAIS	31.8	RAIS				
bromoform	75-25-2	0.0219	RAIS	31.8	RAIS				
bromomethane	74-83-9	0.300	RAIS	13.2	RAIS				
butadiene, 1,3-	106-99-0	3.01	RAIS	39.6	RAIS				
cadmium	7440-43-9	-		-		-		-	
carbon disulfide	75-15-0	0.589	RAIS	21.7	RAIS				

Substance	Chemical Abstract Service # (CAS)	Henry's Law Constant H′ (-)		Organic Carbon Partitioning Coefficient Koc (L/kg)		Biodegradation Half-life Unsaturated t1/2u (days)		Biodegradation Half-life Saturated t1/2s (days)	
		Value	Reference	Value	Reference	Value	Reference	Value	Reference
carbon tetrachloride	56-23-5	1.13	RAIS	43.9	RAIS	6	Axiom	11	Axiom
chloride ion	16887-00-6	-		-		-		-	
chlorobenzene	108-90-7	0.127	RAIS	234	RAIS				
chlorobenzotrifluoride, 4-	98-56-6	1.42	RAIS	1,610	RAIS				
chlorobutane, 1-	109-69-3	0.683	RAIS	72.2	RAIS				
chloroform	67-66-3	0.150	RAIS	31.8	RAIS	32	Axiom	63	Axiom
chloronaphthalene, 2-	91-58-7	0.0131	RAIS	2,480	RAIS				
chloronitrobenzene, 2-	88-73-3	3.80E-04	RAIS	371	RAIS				
chloronitrobenzene, 4-	100-00-5	2.00E-04	RAIS	363	RAIS				
chlorophenol, 2-	95-57-8	4.58E-04	RAIS	Table A-2					
chlorophenol, 3-	108-43-0	1.41E-05	RAIS	300	RAIS				
chlorophenol, 4-	106-48-9	2.56E-05	RAIS	300	RAIS				
chloroprene	126-99-8	2.29	RAIS	60.7	RAIS				
chlorotoluene, 2-	95-49-8	0.146	RAIS	383	RAIS				
chromium, hexavalent	18540-29-9	-		-		-		-	
chromium, trivalent	16065-83-1	-		-		-		-	
cobalt	7440-48-4	-		-		-		-	
copper	7440-50-8	-		-		-		-	
cyanide	57-12-5	0.989	RAIS	-		-		-	
chrysene	218-01-9	2.14E-04	RAIS	181,000	RAIS				
crotonaldehyde, trans-	123-73-9	7.93E-04	RAIS	1.79	RAIS				
dibenz(a,h)anthracene	53-70-3	5.77E-06	RAIS	1,910,000	RAIS				
dibromo-3-chloropropane, 1,2-	96-12-8	0.00601	RAIS	116	RAIS				
dibromobenzene, 1,4-	106-37-6	0.0365	RAIS	375	RAIS				
dibromochloromethane [DBCM]	124-48-1	0.0320	RAIS	31.8	RAIS				
dibromoethane, 1,2-	106-93-4	0.0266	RAIS	39.6	RAIS				
dichlorobenzene, 1,2-	95-50-1	0.0785	RAIS	383	RAIS				
dichlorobenzene, 1,3-	541-73-1	0.108	RAIS	375	RAIS				
dichlorobenzene, 1,4-	106-46-7	0.0990	RAIS	375	RAIS				
dichlorodifluoromethane	75-71-8	14.0	RAIS	43.9	RAIS				
dichlorodiphenyltrichloroethane, total [DDT][2]	-[3]	3.40E-04	RAIS	169,000	RAIS				
dichloroethane, 1,1-	75-34-3	0.230	RAIS	31.8	RAIS	115	Axiom	230	Axiom
dichloroethane, 1,2-	107-06-2	0.0482	RAIS	39.6	RAIS	60	Axiom	120	Axiom

Substance	Chemical Abstract Service # (CAS)	Henry's Law Constant H′ (-)		Organic Carbon Partitioning Coefficient Koc (L/kg)		Biodegradation Half-life Unsaturated t1/2u (days)		Biodegradation Half-life Saturated t1/2s (days)	
		Value	Reference	Value	Reference	Value	Reference	Value	Reference
dichloroethylene, 1,1-	75-35-4	1.07	RAIS	31.8	RAIS				
dichloroethylene, 1,2-cis-	156-59-2	0.167	RAIS	39.6	RAIS				
dichloroethylene, 1,2-trans-	156-60-5	0.383	RAIS	39.6	RAIS				
dichloromethane	75-09-2	0.133	RAIS	21.7	RAIS	55	Axiom	110	Axiom
dichlorophenol, 2,3-	576-24-9	1.26E-05	RAIS	502	RAIS				
dichlorophenol, 2,4-	120-83-2	1.75E-04	RAIS	Table A-2		1,820	Axiom	3,640	Axiom
dichlorophenol, 2,5-	583-78-8	1.26E-05	RAIS	492	RAIS				
dichlorophenol, 2,6-	87-65-0	1.09E-04	RAIS	502	RAIS				
dichlorophenol, 3,4-	95-77-2	1.26E-05	RAIS	492	RAIS				
dichloropropane, 1,2-	78-87-5	0.115	RAIS	60.7	RAIS				
dichloropropene, 1,3- (cis + trans)	542-75-6	0.145	RAIS	72.2	RAIS				
dicyclopentadiene	77-73-6	2.56	RAIS	1,510	RAIS				
diethyl ether	60-29-7	0.0503	RAIS	9.70	RAIS				
diisopropanolamine [DIPA]	110-97-4	2.92E-09	PHYSPROP	10	TOXNET				
dimethylaniline, N,N- [DMA]	121-69-7	0.00232	RAIS	78.7	RAIS				
ethyl acetate	141-78-6	0.00548	RAIS	5.58	RAIS				
ethyl acrylate	140-88-5	0.0139	RAIS	10.7	RAIS				
ethylbenzene	100-41-4	0.322	RAIS	446	RAIS	145	Axiom	290	Axiom
ethylene glycol	107-21-1	2.45E-06	RAIS	1.00	RAIS	105	Axiom	210	Axiom
fluoranthene	206-44-0	3.62E-04	RAIS	55,500	RAIS	115	Axiom	230	Axiom
fluorene	86-73-7	0.00393	RAIS	9,160	RAIS	175	Axiom	350	Axiom
fluoride	16984-48-8	-		-		-		-	
HEPHs	-[3]	0.012	CCME	15,800	CCME				
hexachlorobenzene	118-74-1	0.0695	RAIS	6,200	RAIS				
hexachlorobutadiene	87-68-3	0.421	RAIS	845	RAIS				
hexachlorocyclopentadiene	77-47-4	1.10	RAIS	1,400	RAIS				
hexachloroethane	67-72-1	0.159	RAIS	197	RAIS				
iron	7439-89-6	-		-		-		-	
isobutanol	78-83-1	4.00E-04	RAIS	2.92	RAIS				
isopropylbenzene	98-82-8	0.470	RAIS	698	RAIS				
lead	7439-92-1	-		-		-		-	
LEPHs/LEPHw/EPHw10-19	-[3]	0.057	CCME	2,500	CCME	175	Axiom	350	Axiom
manganese	7439-96-5	-		-		-		-	

Substance	Chemical Abstract Service # (CAS)	Henry's Law Constant H′ (-)		Organic Carbon Partitioning Coefficient Koc (L/kg)		Biodegradation Half-life Unsaturated t1/2u (days)		Biodegradation Half-life Saturated t1/2s (days)	
		Value	Reference	Value	Reference	Value	Reference	Value	Reference
mercury	7439-97-6	0.467	RAIS	-		-		-	
methacrylonitrile	126-98-7	0.0101	RAIS	13.1	RAIS				
methanol	67-56-1	1.86E-04	RAIS	1.00	RAIS	125	Axiom	250	Axiom
methomyl	16752-77-5	8.05E-10	RAIS	10	RAIS				
methyl acetate	79-20-9	0.00470	RAIS	3.06	RAIS				
methyl ethyl ketone [MEK]	78-93-3	0.00233	RAIS	4.51	RAIS	65	Axiom	130	Axiom
methyl methacrylate	80-62-6	0.0130	RAIS	9.14	RAIS				
methyl tert-butyl ether [MTBE]	1634-04-4	0.0240	RAIS	11.6	RAIS	345	Axiom	690	Axiom
methylstyrene, alpha-	98-83-9	0.104	RAIS	698	RAIS				
molybdenum	7439-98-7	-		-		-		-	
naphthalene	91-20-3	0.0180	RAIS	1,540	RAIS	175	Axiom	350	Axiom
nickel	7440-02-0	-		-		-		-	
nitrobenzene	98-95-3	9.81E-04	RAIS	226	RAIS	95	Axiom	190	Axiom
nitroso-di-N-butylamine, N-	924-16-3	5.40E-04	RAIS	915	RAIS				
nitrotoluene, 2-	88-72-2	5.11E-04	RAIS	371	RAIS				
nitrotoluene, 3-	99-08-1	3.80E-04	RAIS	363	RAIS				
nitrotoluene, 4-	99-99-0	2.30E-04	RAIS	363	RAIS				
nonylphenol and nonylphenol ethoxylates4	84852-15-3	4.65E-05	PHYSPROP	25,0005	TOXNET				
pentachlorobenzene, 1,2,3,4,5-	608-93-5	0.0287	RAIS	3,710	RAIS				
pentachlorophenol [PCP]	87-86-5	1.00E-06	RAIS	Table A-2		383	P28	767	P28
perfluorooctane sulfonate [PFOS]	1763-23-1	0.449	RAIS	71,700	RAIS				
phenanthrene	85-01-8	0.00173	RAIS	16,700	RAIS				
phenol	108-95-2	1.36E-05	RAIS	187	RAIS	265	Axiom	530	Axiom
propylene glycol, 1,2-	57-55-6	5.27E-07	RAIS	1	RAIS				
propylene oxide	75-56-9	0.00285	RAIS	5.19	RAIS				
pyrene	129-00-0	4.87E-04	RAIS	54,300	RAIS				
pyridine	110-86-1	4.50E-04	RAIS	71.7	RAIS				
selenium	7782-49-2	-		-		-		-	
silver	7440-22-4	-		-		-		-	
sodium ion	17341-25-2	-		-		-		-	
strontium	7440-24-6	-		-		-		-	
styrene	100-42-5	0.112	RAIS	446	RAIS				

Substance	Chemical Abstract Service # (CAS)	Henry's Law Constant H′ (-)		Organic Carbon Partitioning Coefficient Koc (L/kg)		Biodegradation Half-life Unsaturated t1/2u (days)		Biodegradation Half-life Saturated t1/2s (days)	
		Value	Reference	Value	Reference	Value	Reference	Value	Reference
sulfolane	126-33-0	1.98E-04	RAIS	9.08	RAIS				
tetrachlorobenzene, 1,2,3,4-	634-66-2	0.0311	RAIS	2,270	RAIS				
tetrachlorobenzene, 1,2,4,5-	95-94-3	0.0409	RAIS	2,220	RAIS				
tetrachloroethane, 1,1,1,2-	630-20-6	0.102	RAIS	86.0	RAIS				
tetrachloroethane, 1,1,2,2-	79-34-5	0.0150	RAIS	94.9	RAIS				
tetrachloroethylene	127-18-4	0.724	RAIS	94.9	RAIS				
tetrachlorophenol, 2,3,4,5-	4901-51-3	6.91E-06	RAIS	Table A-2					
tetrachlorophenol, 2,3,4,6-	58-90-2	3.61E-04	RAIS	Table A-2					
tetrahydrofuran	109-99-9	0.00288	RAIS	10.8	RAIS				
thallium	7440-28-0	-		-		-		-	
tin	7440-31-5	-		-		-		-	
toluene	108-88-3	0.271	RAIS	234	RAIS	65	Axiom	130	Axiom
trichlorobenzene, 1,2,3-	87-61-6	0.0511	RAIS	1,380	RAIS				
trichlorobenzene, 1,2,4-	120-82-1	0.0581	RAIS	1,360	RAIS				
trichloroethane, 1,1,1-	71-55-6	0.703	RAIS	43.9	RAIS	80	Axiom	160	Axiom
trichloroethane, 1,1,2-	79-00-5	0.0337	RAIS	60.7	RAIS				
trichloroethylene	79-01-6	0.403	RAIS	60.7	RAIS				
trichlorofluoromethane	75-69-4	3.97	RAIS	43.9	RAIS	2,165	Axiom	4,330	Axiom
trichlorophenol, 2,4,5-	95-95-4	6.62E-05	RAIS	Table A-2					
trichlorophenol, 2,4,6-	88-06-2	1.06E-04	RAIS	Table A-2					
trichloropropane, 1,1,2-	598-77-6	0.0130	RAIS	94.9	RAIS				
trichloropropane, 1,2,3-	96-18-4	0.0140	RAIS	116	RAIS				
trichloropropene, 1,2,3-	96-19-5	0.720	RAIS	116	RAIS				
trimethylbenzene, 1,3,5-	108-67-8	0.359	RAIS	602	RAIS				
tungsten	7440-33-7	-		-		-		-	
uranium	7440-61-1	-		-		-		-	
vanadium	7440-62-2	-		-		-		-	
vinyl acetate	108-05-4	0.0209	RAIS	5.58	RAIS				
vinyl chloride	75-01-4	1.14	RAIS	21.7	RAIS				
VPHs/VPHw/VHw6-10	-[3]	0.51	CCME	1,600	CCME	90	Axiom	180	Axiom
xylenes, total	1330-20-7	0.271	RAIS	383	RAIS	145	Axiom	290	Axiom
zinc	7440-66-6	-		-		-		-	

[1] Substance properties based on benzo(b)fluoranthene.
[2] Sum of DDT (2,4′ + 4,4′ isomers), DDD (2,4′ + 4,4′ isomers) and DDE (2,4′ + 4,4′ isomers).
[3] No CAS number exists for this substance.
[4] Nonylphenol includes related nonylphenolic and octylphenolic compounds, including ethoxylates and ethoxycarboxylates. Consult the director for further advice.
[5] Koc range provided in ToxNet is 10,000 to 50,000 L/kg. Midpoint value of 25,000 selected.
- not applicable

Reference sources:

Koc and H′ substance property values from RAIS [2] except for DIPA, nonylphenol, LEPHs/LEPHw/EPHw10-19 and VPHs/VPHw/VHw6-10 (see reference sources below). Substance property data downloaded Feb 22/16 for anthracene, benzene, benzo(a)pyrene, DDT, ethylbenzene, ethylene glycol, fluoranthene, methanol, naphthalene, PCP, PFOS, phenol, sulfolane, tetrachloroethylene, toluene, trichloroethylene, and xylenes. Substance property data for remaining substances downloaded May 3/17.

H′ substance property values for DIPA and nonylphenol from SRC PHYSPROP [6]. Substance property data downloaded Feb 23/16.

Koc substance property values for DIPA and nonylphenol from SRC HSDB TOXNET [7]. Substance property data downloaded Feb 23/16.

HEPHs, LEPHs/LEPHw and VPHs/VPHw substance property values from CCME [8]. LEPHw and VPHw values used as surrogate values for VHw6-10 and EPHw10-19, respectively.

Half-life (biodegradation rates) from Axiom [9] or, for pentachlorophenol, Protocol 28.

Appendix A

Table A-2 Substance properties (select chlorophenols)

Soil pH (-)	Organic Carbon Partitioning Coefficient Koc (L/kg)						
	chlorophenol, 2- (CAS#95-57-8)	dichlorophenol, 2,4- (CAS#120-83-2)	pentachlorophenol [PCP] (CAS#87-86-5)	tetrachlorophenol, 2,3,4,5- (CAS#4901-51-3)	tetrachlorophenol, 2,3,4,6- (CAS#58-90-2)	trichlorophenol, 2,4,5- (CAS#95-95-4)	trichlorophenol, 2,4,6- (CAS#88-06-2)
4.9	398	159	9,050	17,300	4,450	2,370	1,040
5.0	398	159	7,960	17,200	4,150	2,360	1,030
5.1	398	159	6,930	17,000	3,830	2,360	1,020
5.2	398	159	5,970	16,700	3,490	2,350	1,010
5.3	398	159	5,100	16,500	3,140	2,340	999
5.4	398	158	4,320	16,100	2,790	2,330	982
5.5	397	158	3,650	15,700	2,450	2,320	962
5.6	397	158	3,070	15,200	2,130	2,310	938
5.7	397	158	2,580	14,700	1,830	2,290	910
5.8	397	158	2,180	14,000	1,560	2,270	877
5.9	397	157	1,840	13,200	1,320	2,240	839
6.0	396	157	1,560	12,400	1,110	2,210	796
6.1	396	157	1,330	11,500	927	2,170	748
6.2	396	156	1,150	10,500	775	2,120	697
6.3	395	155	998	9,510	647	2,060	644
6.4	394	154	877	8,480	542	1,990	589
6.5	393	153	781	7,470	455	1,910	533
6.6	392	152	703	6,490	384	1,820	480
6.7	390	150	640	5,580	327	1,710	429
6.8	388	147	592	4,740	280	1,600	381
6.9	386	145	552	3,990	242	1,470	338
7.0	383	141	521	3,330	213	1,340	300
7.1	379	138	496	2,760	188	1,210	267
7.2	375	133	476	2,280	169	1,070	239
7.3	369	128	461	1,870	153	943	215
7.4	362	121	447	1,530	141	819	195
7.5	354	114	437	1,250	131	703	178
7.6	344	107	429	1,020	123	599	164
7.7	333	98.4	423	831	117	507	153

Soil pH (-)	Organic Carbon Partitioning Coefficient Koc (L/kg)						
	chlorophenol, 2- (CAS#95-57-8)	dichlorophenol, 2,4- (CAS#120-83-2)	pentachlorophenol [PCP] (CAS#87-86-5)	tetrachlorophenol, 2,3,4,5- (CAS#4901-51-3)	tetrachlorophenol, 2,3,4,6- (CAS#58-90-2)	trichlorophenol, 2,4,5- (CAS#95-95-4)	trichlorophenol, 2,4,6- (CAS#88-06-2)
7.8	319	89.7	418	679	113	426	144
7.9	304	80.7	414	556	108	357	137
8.0	286	71.7	410	458	105	298	131
8.1	267	63.0	408	379	103	249	126
8.2	246	54.7	406	316	101	208	122
8.3	224	47.0	404	265	99.1	175	119
8.4	202	40.0	403	225	97.8	148	117
8.5	180	33.8	402	192	96.8	126	115
8.6	158	28.4	401	167	96.1	108	113
8.7	137	23.8	400	146	95.4	93.4	112
8.8	118	19.9	400	130	94.9	81.9	111
8.9	100	16.6	400	117	94.5	72.6	110
9.0	84.7	13.9	399	107	94.2	65.1	109

Reference source: USEPA SSG [10]. Koc values for pH 8.1 to 9.0 calculated using Equations 72 and 74 and Table 41 of Part 5 of the Technical Background Document.

Appendix A

Table A-3 Substance properties (inorganics) distribution coefficients

Substance	Chemical Abstract Service # (CAS)	Kd (L/kg)	Reference Source
aluminum	7429-90-5	1,500	RAIS [2]
antimony	7440-36-0	45	USEPA SSG [10]
arsenic	7440-38-2	*	USEPA SSG [10]
barium	7440-39-3	100	MoE [11]
beryllium	7440-41-7	*	USEPA SSG [10]
boron	7440-42-8	3	RAIS [2]
cadmium	7440-43-9	*	USEPA SSG [10]
chloride ion	16887-00-6	0.05	MoE [12]
chromium, hexavalent	18540-29-9	*	USEPA SSG [10]
chromium, trivalent	16065-83-1	*	USEPA SSG [10]
cobalt	7440-48-4	45	RAIS [2]
copper	7440-50-8	*	CSST1996 [13]
cyanide	57-12-5	9.9	USEPA SSG [10]
fluoride	16984-48-8	150	RAIS [2]
iron	7439-89-6	25	RAIS [2]
lead	7439-92-1	*	10*CSST1996 [13]
manganese	7439-96-5	65	RAIS [2]
mercury	7439-97-6	52	RAIS [2]
molybdenum	7439-98-7	20	RAIS [2]
nickel	7440-02-0	*	USEPA SSG [10]
selenium	7782-49-2	*	USEPA SSG [10]
silver	7440-22-4	*	USEPA SSG [10]
sodium ion	17341-25-2	20	Royal Roads [14]
strontium	7440-24-6	35	RAIS [2]
thallium	7440-28-0	*	USEPA SSG [10]
tin	7440-31-5	250	RAIS [2]
tungsten	7440-33-7	150	RAIS [2]
uranium	7440-61-1	450	RAIS [2]
vanadium	7440-62-2	1,000	RAIS [2]
zinc	7440-66-6	*	USEPA SSG [10]

* varies by soil pH – see Protocol 28 (for silver and thallium, see Table A-4).

Appendix A

Table A-4 Substance properties (silver and thallium) distribution coefficients

Soil pH (-)	Kd (L/kg)	
	silver CAS# 7440-22-4	thallium CAS# 7440-28-0
4.9	0.1	44
5.0	0.13	45
5.1	0.16	46
5.2	0.21	47
5.3	0.26	48
5.4	0.33	50
5.5	0.42	51
5.6	0.53	52
5.7	0.67	54
5.8	0.84	55
5.9	1.1	56
6.0	1.3	58
6.1	1.7	59
6.2	2.1	61
6.3	2.7	62
6.4	3.4	64
6.5	4.2	66
6.6	5.3	67
6.7	6.6	69
6.8	8.3	71
6.9	10	73
7.0	13	74
7.1	16	76
7.2	20	78
7.3	25	80
7.4	31	82
7.5	39	85
7.6	48	87
7.7	59	89
7.8	73	91
7.9	89	94
8.0 to 9.0	110	96
Reference Source	USEPA SSG[10]	USEPA SSG[10]

APPENDIX B

Habitat and Receptor Assessment
(Question TS-5 in SLRA Questionnaire)

This assessment evaluates whether the site contains suitable habitat for specific local species. This assessment may only be completed by a registered professional biologist.

The potential for onsite terrestrial habitat to be used by specific receptor groups is evaluated in three steps: (1) determination of potential receptors; (2) selection of site-specific receptors; and, (3) assessment of habitat suitability. The procedure parallels the problem formulation sections and the "effects assessment-site observation" sections described in the Tier 1 ecological risk assessment protocol.

1.0 Determining potential receptors

Potential site receptor groups to be considered vary depending on land use and geographic location of the site. **Form B-1** indicates those wildlife receptors that must be considered on the basis of the different land uses (other receptors may be considered as deemed appropriate by the assessor). The assessor must also complete a site visit and check for the presence of terrestrial plant types on the site.

2.0 Selection of appropriate site-specific receptors

Using **Form B-1** as a reference, the assessor must complete **Form B-2**, which documents the land use and geographic location of the site along with observed receptor groups based on a site visit and interviews with local residents. The assessor must also indicate the potential for the presence of receptors which have not been observed during the site visit or indicated by local or onsite sources. The potential for a receptor's presence is evaluated on the basis of an office review of available information on potential receptor groups (e.g. biogeoclimatic zone lists, Committee on the Status of Endangered Wildlife in Canada [COSEWIC] lists, etc.). The receptor identification should also consider the rules (specified for each land use) within ministry ecological risk assessment protocols and/or guidance. Finally, the assessor must indicate which receptor groups will be carried forward to the assessment of habitat suitability.

Any COSEWIC-listed, red-listed, or blue-listed species that may be present in the vicinity of the site must be listed and considered individually. Guidance for identifying COSEWIC species and their geographic range is available at the following url: http://www.registrelep-sararegistry.gc.ca/sar/index/default_e.cfm. Guidance for identifying red and blue-listed species and their geographic range is available at the following url: https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/species-ecosystems-at-risk.

3.0 Assessment of habitat suitability

The undeveloped land onsite is evaluated in terms of habitat suitability for each of the selected receptor groups on **Form B-2**. The habitat suitability for each receptor group (including any COSEWIC or red/blue-listed species) is evaluated by completing the decision matrix in **Form B-3**. The decision matrix considers the following three factors:

- *Size of the undeveloped land and whether or not it is suitable for the receptor in question*. Factors such as the home range of the species should be considered while evaluating the size criterion. A "yes" answer indicates that the undeveloped land is large enough to support the receptor in question, and a "no" indicates that the land is too small to support the receptor.
- *Degree of fragmentation of the undeveloped land in terms of the specific habitat requirements of the receptor*. A "yes" answer indicates that the land is sufficiently connected or in sufficient proximity of additional habitat features, and a "no" would indicate that the undeveloped land is isolated from any additional habitat requirements of the receptor.
- *Quality of the undeveloped land*. This may include types of vegetation, presence or absence of important habitat features for the receptor, percent cover, and extent of human disturbance or degradation of the land.

The assessor should also state if it is his or her professional opinion as to whether the vegetation at the site is stressed because of site conditions or whether the vegetative conditions are typical for that geographic area at the time of the site inspection. Consideration should be given to aspects such as sites that are subject to physical impacts as a result of: traffic; storage of products on land such as lumber, pipes, etc.; or maintenance requirements (e.g. the Fire Code) that require vegetation at many industrial sites to be controlled.

Following consideration of the three factors above (i.e. size, degree of fragmentation, quality), the assessor should indicate whether or not the receptor in question is likely to use the undeveloped land as habitat.

- If "yes" for any receptor, then enter a "yes" response to Question TS-5 (i.e. the site does contain suitable habitat for specific local species).
- If "no" for all receptors, then enter a "no" response to Question TS-5 (i.e. there are no unacceptable risks to the terrestrial environment via direct exposure).

The assessor must provide rationale on **Form B-3** in support of any decisions made. Forms B-1 through B-3 are included in the SLRA Questionnaire and Forms attachment.

Protocol 13

Screening Level Risk Assessment

Questionnaire and Forms

Screening Level Risk Assessment (SLRA) Questionnaire

		Yes	No	Note
GENERAL				
Complete problem formulation and conceptual site model.				
Check for requirements (section 3.1)				
Check for precluding conditions (section 3.2)				
Check for exemptions (sections 3.3 and 6.0)				
Proceed sequentially through the following exposure scenarios.				0
HUMAN EXPOSURE SCENARIOS				
Exposure to Contaminated Soils (HS-1 to 3)				
HS-1	Do substance concentrations in soil exceed the applicable standards?	☐	☐	1,2
HS-2	Are contaminated soils located within, or may contaminants in soil migrate to within, 1 m of ground surface?	☐	☐	3
HS-3	Is the ground surface above contaminated soils uncovered?	☐	☐	4
Exposure to Contaminated Groundwater (HW-1 to 3)				
HW-1	Does drinking water use apply at the site?	☐	☐	5
HW-2	Do substance concentrations in soil or groundwater exceed the standards for the protection of drinking water?			6,2
HW-3	Is there the potential for soil leachate or contaminated groundwater to migrate to a water well used for drinking water on the parcel or to migrate beyond the parcel boundary, at concentrations greater than the drinking water standards?	☐	☐	7
ECOLOGICAL EXPOSURE SCENARIOS				
Terrestrial Exposure to Contaminated Soils (TS-1 to 5)				
TS-1	Do substance concentrations in soil exceed the applicable standards?	☐	☐	8,2
TS-2	Are contaminated soils located within, or may contaminants in soil migrate to within, 1 m of ground surface?	☐	☐	3
TS-3	Is the ground surface above contaminated soils uncovered?	☐	☐	4
TS-4	Is there *potential terrestrial habitat* present? [This question to be completed by a registered Professional Biologist (RPBio)]	☐	☐	9
TS-5	Does the site contain suitable habitat for specific local species? [This question to be completed by a registered Professional Biologist (RPBio)]	☐	☐	10
Exposure of aquatic biota to contaminated groundwater (AW-1 to 3)				
AW-1	Does aquatic life water use apply at the site?	☐	☐	5
AW-2	Do substance concentrations in soil or groundwater exceed the standards for the protection of aquatic life?	☐	☐	11,2
AW-3	Is there the potential for soil leachate or contaminated groundwater to migrate to a receiving environment on the parcel or to migrate beyond the parcel boundary, at concentrations greater than the Aquatic Life water standards?	☐	☐	7
Exposure of crops to contaminated groundwater (IW-1 to 3)				
IW-1	Does irrigation water use apply at the site?	☐	☐	5
IW-2	Do substance concentrations in soil or groundwater exceed the standards for the protection of irrigation?	☐	☐	12,2
IW-3	Is there the potential for soil leachate or contaminated groundwater to migrate to a water well used for irrigation on the parcel or to migrate beyond the parcel boundary, at concentrations greater than the irrigation water standards?	☐	☐	7

Screening Level Risk Assessment (SLRA) Questionnaire (Continued)

Exposure of livestock to contaminated groundwater (LW-1 to 3)				
LW-1	Does livestock water use apply at the site?	☐	☐	5
LW-2	Do substance concentrations in soil or groundwater exceed the standards for the protection of livestock watering?	☐	☐	13,2
LW-3	Is there the potential for soil leachate or contaminated groundwater to migrate to a water well used for livestock watering on the parcel or to migrate beyond the parcel boundary, at concentrations greater than the livestock watering water standards?	☐	☐	7
DEFAULT STANDARDS				
DF-1	Do VHw6-10 or EPHw10-19 concentrations in groundwater exceed the default generic numerical water standards for these substances?	☐	☐	
DF-2	Is there the potential for soil leachate or contaminated groundwater to migrate beyond the parcel boundary at concentrations greater than the VHw6-10 or EPHw10-19 water standards?	☐	☐	7

SLRA Questionnaire Notes

0. If a "no" response is provided to a given question within a series, then the remaining questions in that series need not be answered.
1. Use the applicable land use soil standards in Schedule 3.1 Part 1 (Intake of contaminated soil) and Schedule 3.1 Part 2 or background soil concentrations established under Protocol 4.
2. Any applicable Directors' interim standards or criteria must also be applied.
3. This question includes evaluation of the potential for wicking of contaminants into the upper 1 m of soil due to capillary action. Cross-sections showing the vertical extent of soil contamination must be provided to support a "no" response to this question.
4. This question evaluates if there is a permanent barrier (e.g. pavement or concrete) at ground surface, above the contaminated soils, to prevent potential exposure to contaminants. A scaled plan map showing the lateral extent of contaminated soils, barriers present, and absence of bare or vegetated soil at ground surface must be provided to support a "no" response to this question.
5. For evaluation of water uses, see Protocol 21, "Water Use Determination".
6. For soils, use the applicable land use soil standards in Schedule 3.1 Part 1 (Groundwater used for drinking water) and Schedule 3.1 Part 2, background soil concentrations established under Protocol 4, or the site-specific numerical soil standards developed under Protocol 2 for the "Groundwater used for drinking water" site-specific factor. For groundwater, use the water standards in Schedule 3.2 (Column 6 Drinking Water) or background groundwater concentrations established under Protocol 9.
7. This question is answered by evaluating: (a) soil leachate concentrations (**Form A-1**); and (b) contaminant transport along a groundwater flow path to the respective receptor (**Form A-2**). The forms, and details on how to complete them, are provided in **Appendix A**. Provide completed forms (**Form A-1 and A-2**) to support a "no" response to this question. See Figure 3 for graphical depiction of the soil leachate and groundwater transport assessment process.
8. Use the applicable land use soil standards in Schedule 3.1 Part 1 (Toxicity to soil invertebrates and plants, Livestock ingesting soil and fodder or Major microbial functional impairment) and Schedule 3.1 Part 3 or background soil concentrations established under Protocol 4.
9. See Figure 4 for graphical depiction of the potential terrestrial habitat evaluation process.
10. This question is answered by: (1) determining possible site receptors based on land use (**Form B-1**); (2) selecting appropriate receptors (**Form B-2**); and (3) assessing habitat suitability for each receptor (**Form B-3**). The forms, and details on how to complete them, are provided in **Appendix B**. Provide completed forms (**Form B-1 through B-3**) to support a "no" response to this question.
11. For soils, use the applicable land use soil standards in Schedule 3.1 Part 1 (Groundwater flow to surface water used by aquatic life) and Schedule 3.1 Part 3, background soil concentrations established under Protocol 4, or the site-specific numerical soil standards developed under Protocol 2 for the "Groundwater flow to surface water used by aquatic life" site-specific factor. For groundwater, use the water standards in Schedule 3.2 (Column 3 Aquatic Life) and, as applicable, Protocol 10, or background groundwater concentrations established under Protocol 9.
12. For soils, use the applicable land use standards in Schedule 3.1 Part 1 (Groundwater used for irrigation) and Schedule 3.1 Part 3, background soil concentrations established under Protocol 4, or the site-specific numerical soil standards developed under Protocol 2 for the "Groundwater used for irrigation" site-specific factor. For groundwater, use the water standards in Schedule 3.2 (Column 4 Irrigation) or background groundwater concentrations established under Protocol 9.
13. For soils, use the applicable land use standards in Schedule 3.1 Part 1 (Groundwater used for livestock watering) and Schedule 3.1 Part 3, background soil concentrations established under Protocol 4, or the site-specific numerical soil standards developed under Protocol 2 for the "Groundwater used for livestock watering" site-specific factor. For groundwater, use the water standards in Schedule 3.2 (Column 5 Livestock) or background groundwater concentrations established under Protocol 9.

Form A-1. Soil Leachate Concentrations, Transport and Mixing

Question being answered (e.g. AW-3): ____________ **Applicable CSR Water Standard (circle):** **DW** **AW** **LW** **IW**

Parameter	Units	Default Value	Site-Specific Value	Minimum Value
Water-filled porosity, n_w	-	0.119		
Air-filled porosity, n_a	-	0.241		
Dry bulk density of soil, ρ_b	g/cm^3	1.7		
Fraction of organic carbon, f_{oc}	-	0.005		
Depth to water table, d	m			
Source depth, Z	m			
Source length, X	m			
Aquifer thickness, d_a	m			
Infiltration rate, I	m/yr			0.08
Darcy flux, V (=K*i)	m/yr			

Soil Sample Locations/ ID	**Contaminant**	**C_S** Soil concentration at source (µg/g)	**C_L** Leachate concentration at source[1] (µg/L)	**C_z** Leachate concentration at water table (Eqn A-2) (µg/L)	**d_m**[2] Mixing zone thickness (Eqn A-4) (m)	**DF**[3] Dilution Factor	**$C_{gw'}$** Predicted groundwater concentration below source (Eqn A-3) (µg/L)	**CSR Water Standard**[4] (µg/L)

[1] Include specification of calculation method (Appendix A section 1.1, 1.2 or 1.3).

[2] If mixing thickness is greater than the aquifer thickness, enter $d_m = d_a$.

[3] If the soil contamination source extends below the water table, enter DF=1.

[4] Use CSR numerical water standards listed in Schedule 3.2, Protocol 10, as applicable, or background groundwater concentrations established under Protocol 9, for the pathway being assessed (i.e., DW, AW, LW, IW).

Form A-2. Groundwater Transport

Question being answered (e.g. AW-3): ____________ **Applicable CSR Water Standard (circle):** **DW** **AW** **LW** **IW**

Parameter	Units	Default Value	Site-Specific Value	Minimum Value
Total porosity, n	-	0.36		
Effective porosity, n_e	-	0.25		
Dry bulk density of soil, ρ_b		1.7		
Fraction of organic carbon, f_{oc}	-	0.005		
Source width[1], Y	m			
Average linear groundwater velocity, $v=K*i/n_e$	m/yr			5

Soil or Groundwater Sample Locations/ID	Contaminant	$C_{gw'}$ Predicted groundwater concentration below source (from Form A-1) (µg/L)	C_{gwmax} Maximum measured groundwater concentration below source (µg/L)	C_{gw} Groundwater concentration below source[2] (µg/L)	x Distance to point of compliance[3] (m)	C_x Predicted groundwater concentration at point of compliance (Eqn A-5) (µg/L)	CSR Water Standard[4] (µg/L)

[1] Maximum extent of contaminated groundwater in the source zone perpendicular to the groundwater flow direction.

[2] Enter the maximum measured groundwater concentration based on site investigation data (C_{gwmax}) or groundwater concentration predicted from soil leaching ($C_{gw'}$), whichever is greatest.

[3] Allowable range is 10 m ≤ x ≤ 500 m and depends on water use. See Appendix A section 4.0 for allowable distance values.

[4] Use CSR numerical water standards listed in Schedule 3.2, Protocol 10, as applicable, or background groundwater concentrations established under Protocol 9, for the pathway being assessed (i.e., DW, AW, LW, IW).

Form B-1. Recommended Receptors Based on Current Land Use

Wildlife receptors	Industrial	Commercial	Residential[1]	Agricultural	Urban Park / Wildlands[2]
Terrestrial salamanders	Yes	Yes	Yes	Yes	Yes
Frogs/Toads	Yes	Yes	Yes	Yes	Yes
Reptiles	Yes	Yes	Yes	Yes	Yes
Waterfowl	If adjacent to water	If adjacent to water	If adjacent to water	Yes	If adjacent to water
Marsh birds/Waders	If adjacent to water	If adjacent to water	If adjacent to water	If adjacent to water	If adjacent to water
Upland game birds	No	No	No	Yes	Yes
Raptors (eagles, hawks, falcons, owls)	Yes	Yes	Yes	Yes	Yes
Shorebirds	If adjacent to water	If adjacent to water	If adjacent to water	Yes	If adjacent to water
Songbirds	Yes	Yes	Yes	Yes	Yes
Insectivorous mammals	Yes	Yes	Yes	Yes	Yes
Small herbivorous mammals	Yes	Yes	Yes	Yes	Yes
Bats	Yes	Yes	Yes	Yes	Yes
Small/medium carnivores	No	No	Yes	Yes	Yes
Large carnivores	No	No	No	Yes	Yes
Ungulates	No	No	No	Yes	Yes
COSEWIC / red / blue-listed species (evaluate individually)	Yes	Yes	Yes	Yes	Yes
Soil invertebrates	Yes	Yes	Yes	Yes	Yes
Terrestrial plants: check those that apply (i.e. found onsite during site visit)					
Trees: coniferous					
Trees: deciduous					
Shrubs					
Herbs: forbs					
Herbs: grasses					
Mosses, liverworts					
Lichens					
Fungi					
COSEWIC/red/blue-listed species	Yes	Yes	Yes	Yes	Yes

[1] Residential includes both Residential (Low Density) and Residential (High Density) land uses.

[2] Urban Park / Wildlands includes: Urban Park, Wildlands (Natural) and Wildlands (Reverted) land uses.

Date of site visit(s): ____

Form B-2. Selection of Appropriate Site-Specific Receptors

Land use: ______________________________

Location of site: ______________________________

Wildlife receptors	Based on land use[1]	Observed[2] (by assessor)	Observed (other sources)	Not observed[3]	Professional opinion regarding presence of receptor
Terrestrial salamanders					
Frogs/Toads					
Reptiles					
Waterfowl					
Marsh birds/Waders					
Upland game birds					
Raptors (eagles, hawks, falcons, owls)					
Shorebirds					
Songbirds					
Insectivorous mammals					
Small herbivorous mammals					
Bats					
Small/medium carnivores					
Large carnivores					
Ungulates					
Shrubs					
Grasses					
Ornamentals					
Trees: coniferous					
Trees: deciduous					
Herbs and forbs					
Mosses, lichens and fungi					
Other					
Red- or blue-listed species (B.C. Conservation Data Centre)					
COSEWIC-listed species (evaluate as individuals)					

1 Receptors chosen based on current land use (from **Form B-1**).

2 Specify date of observation/site visit.

3 Receptor not observed. Indicate potential (i.e. “Nil”, “Low” or “High”) that receptor will actually be present at the site based on office review of available information.

Form B-3. Habitat Suitability

(to be completed for each receptor selected from **Form B-2**)

Receptor: ____

Observed onsite or potential for presence onsite: **Yes** ________ **No** ________

Habitat size	Connectivity of fragments	Quality	Move to ecological risk assessment
Yes	Yes	Not applicable	**Yes**
		Not applicable	**Yes**
	No	Yes	**Yes**
		No	**No**
No	Yes	Yes	**Yes**
		No	**No**
	No	Not applicable	**No**
		Not applicable	**No**

Note: "Yes" indicates that the habitat or habitat characteristic is favourable for a species.

Ecological risk assessment required? Yes________ No_______

Physical signs of impacts on plants or invertebrates? Yes________ No_______

Comments:

FIGURE 1. Screening Level Risk Assessment Flowchart.
(Note: This flowchart is provided for illustrative purposes only. The questionnaire included in SLRA must be completed and takes precedence over this flowchart).

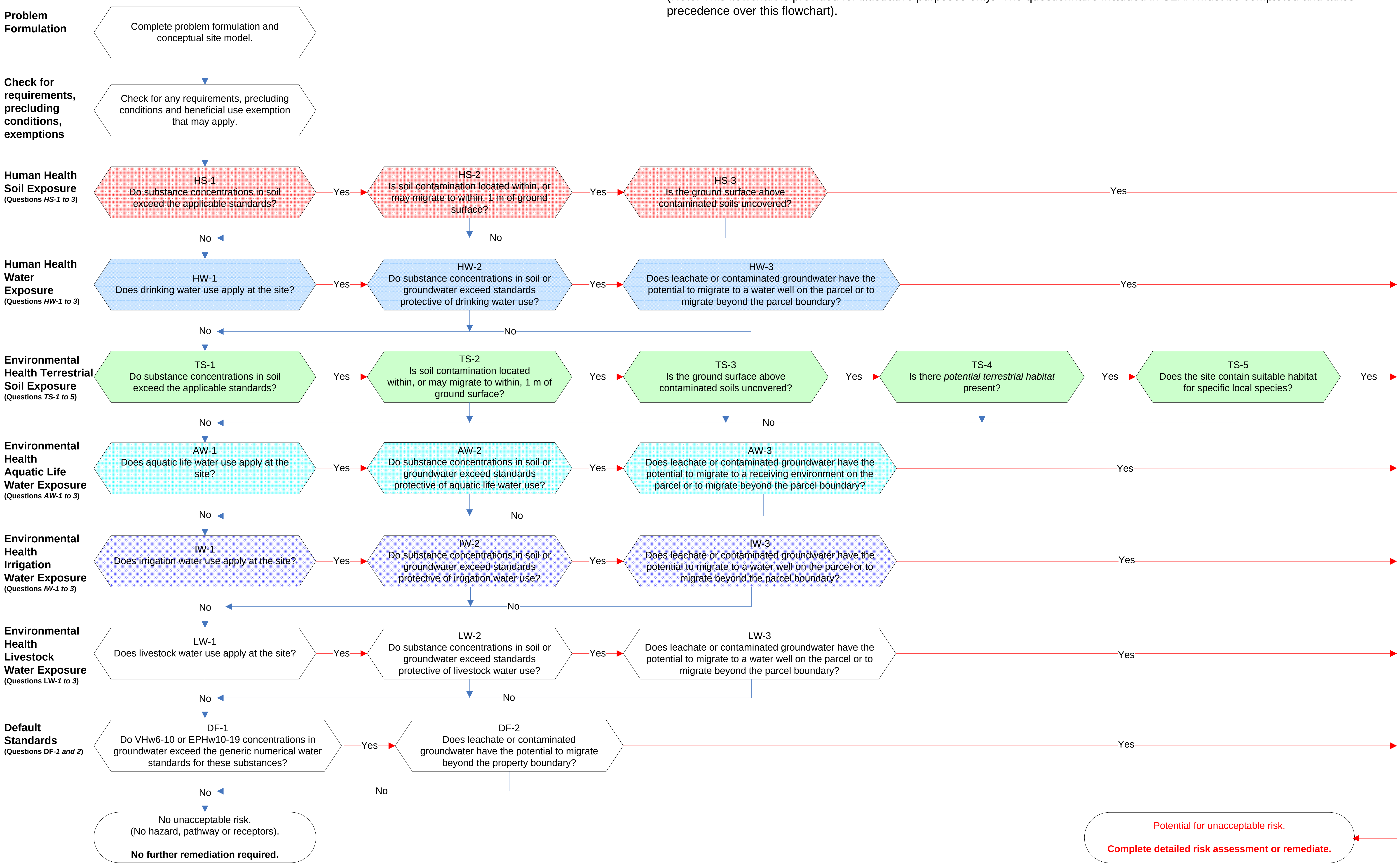
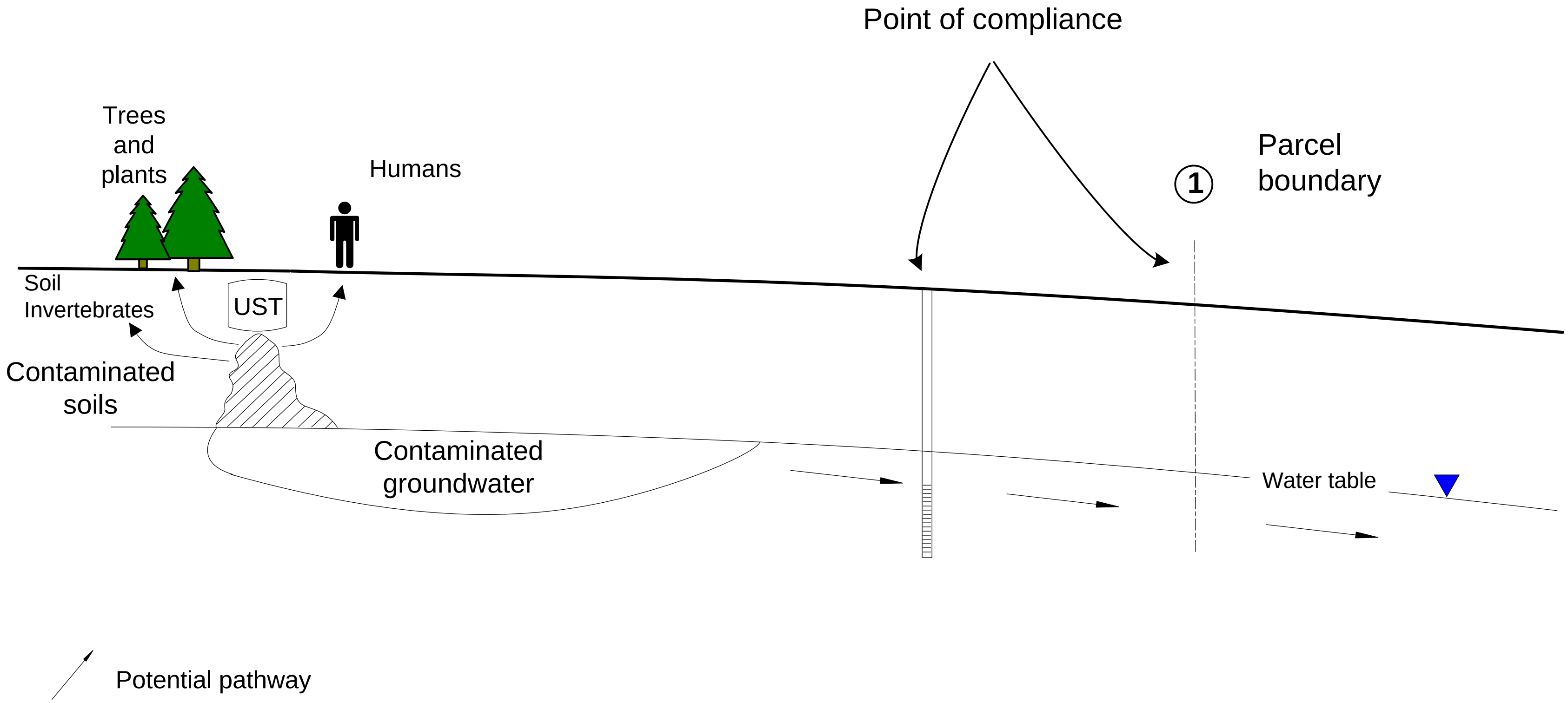


FIGURE 2. Conceptual Site Model (example).



<u>Notes</u>

1. See Section 3.2 for restrictions on screening of drinking water, aquatic life, irrigation, livestock watering and default pathways where contaminated groundwater has migrated beyond the parcel boundary (at sites where DW, AW, IW or LW standards are applicable).

FIGURE 3. Soil Leachate and Groundwater Transport Assessment Flowchart.
(Note: This flowchart is provided for illustrative purposes only. The process description in Appendix A take precedence over this flowchart).

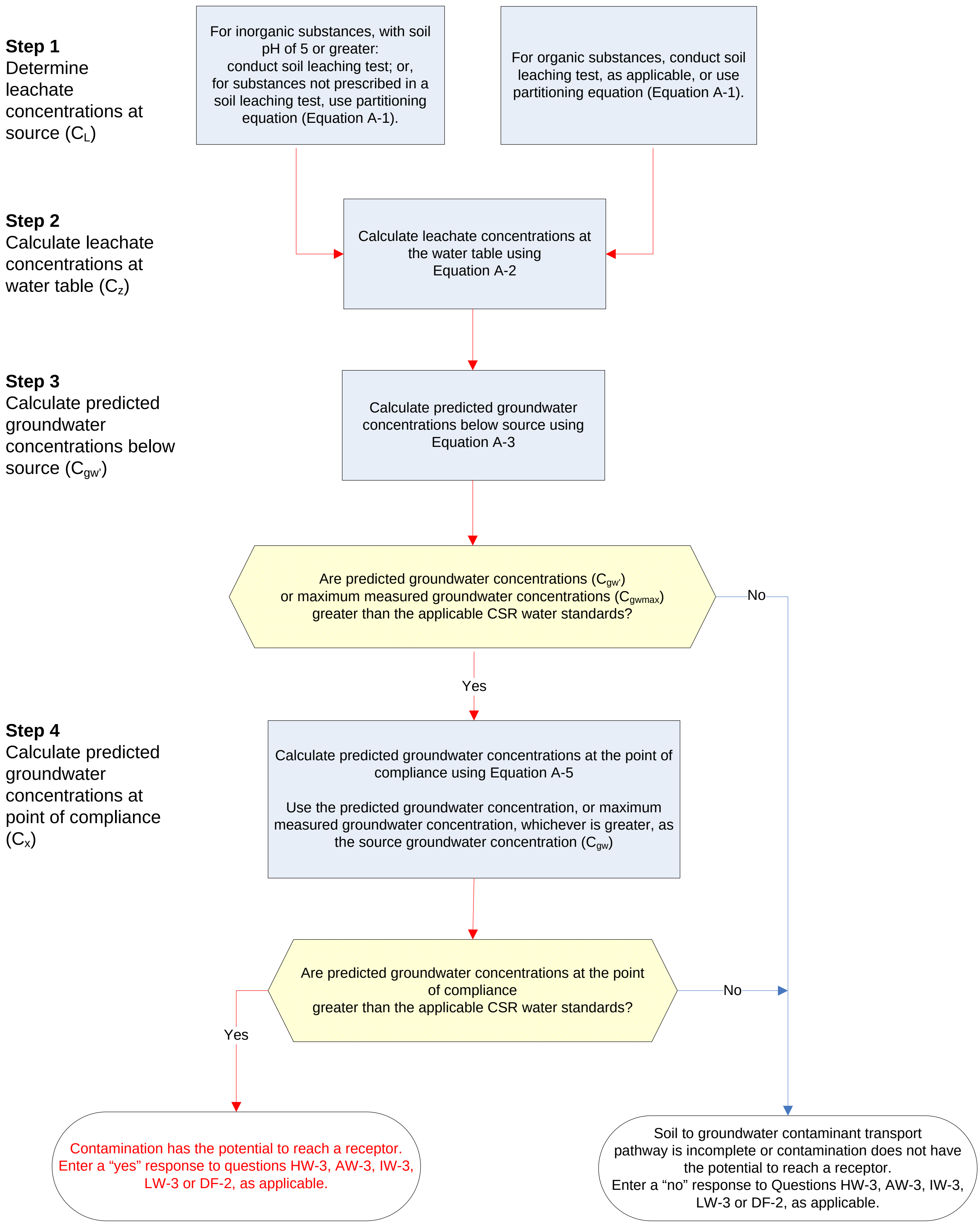


FIGURE 4. Potential Terrestrial Habitat Evaluation Flowchart.
(Note: This flowchart is provided for illustrative purposes only. The definitions and questionnaire in SLRA take precedence over this flowchart).